FUNCTIONAL DIVERGENCE, STRUCTURAL CONVERGENCE AND PRE-ADAPTATION EXHIBITED BY THE FISHES OF THE CYPRINOID FAMILY PSILORHYNCHIDAE HORA

BY

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(*With two text figures*)

The family Psilorhynchidae, as defined at present, consists of a single genus *Psilorhynchus* McClelland which comprises three species, namely, *P. sucatio* (Ham.), *P. balitora* (Ham.) and *P. homaloptera* Hora & Mukerji. Hamilton's two species were originally described from the north-eastern parts of Bengal (Eastern Himalayas), and have since been very frequently collected from the small streams below the Darjeeling Himalayas. The range of *P. sucatio* has now been extended to the Gandak drainage by Menon (seen in MS.) and to the Damodar River basin by David (seen in MS.), while *P. balitora* has since been found in the Assam Hills (Hora 1921*a*), Upper Burma (Mukerji, 1933) and as far west along the Himalayas as Delhi (Majumdar, 1952), *P. homaloptera* is known so far only from the Naga Hills, Assam (Hora & Mukerji, 1935). It will thus be seen that Psilorhynchidae is a small family of peculiar fishes with a comparatively restricted distribution. The distributional pattern of the family, when compared with that of the Homalopteridae or the Glyptosternoid group of the family Sisoridae, indicates its evolution during the Pleistocene and its dispersal and speciation during the late orogenic movements of the Himalayas (Menon, op. cit., MS.). It seems to have crossed over the Garo-Rajmahal Gap during the last glacial epoch about 20,000 to 10,000 years ago when the height of the gap relative to the then sea-level was probably 500 to 600 feet (Hora, 1951).

These remarkable fishes have been variously assigned to the families Cyprinidae, Cobitidae and Homalopteridae by the earlier ichthyologists and some fishes from China and Indo-China had erroneously been referred to *Psilorhynchus* owing to certain superficial similarities in structure and form with the Indian species. In 1925, the writer (Hora, pp. 457-60) discussed the systematic position of this genus and created a separate family for its reception. Since then, Mukerji (loc. cit.) and Ramaswami (1952) have shown from more detailed morphological studies that its separation into a new family was justified. The salient features of the Psilorhynchidae are :—

1. Absence of barbels and peculiar shape of mouth and of the associated structures (text fig. 1 *d-f*).
2. Presence of a number of unbranched rays in the paired fins (text fig. 1 *d-f*) as in the Homalopteridae.
3. A free air-bladder in the abdominal cavity (text fig. I *a-c*) as in the Cyprinidae.

4. A slender pharyngeal bone with teeth (four) arranged in a single row as in the Cobitidae and the Homalopteridae.
5. A plate-like, well-developed and broad basipterygium (text fig. 1 *g*, *h* and *j*) for the attachment of muscles as in the Homalopteridae.

In characters 2, 4 and 5, there is a close parallelism between the families Psilorhynchidae and Homalopteridae, but the structural modifications 2 and 5, though due to the more vigorous use of the paired fins and the muscles associated with them, are correlated with the performance of different functions, as will be shown below.

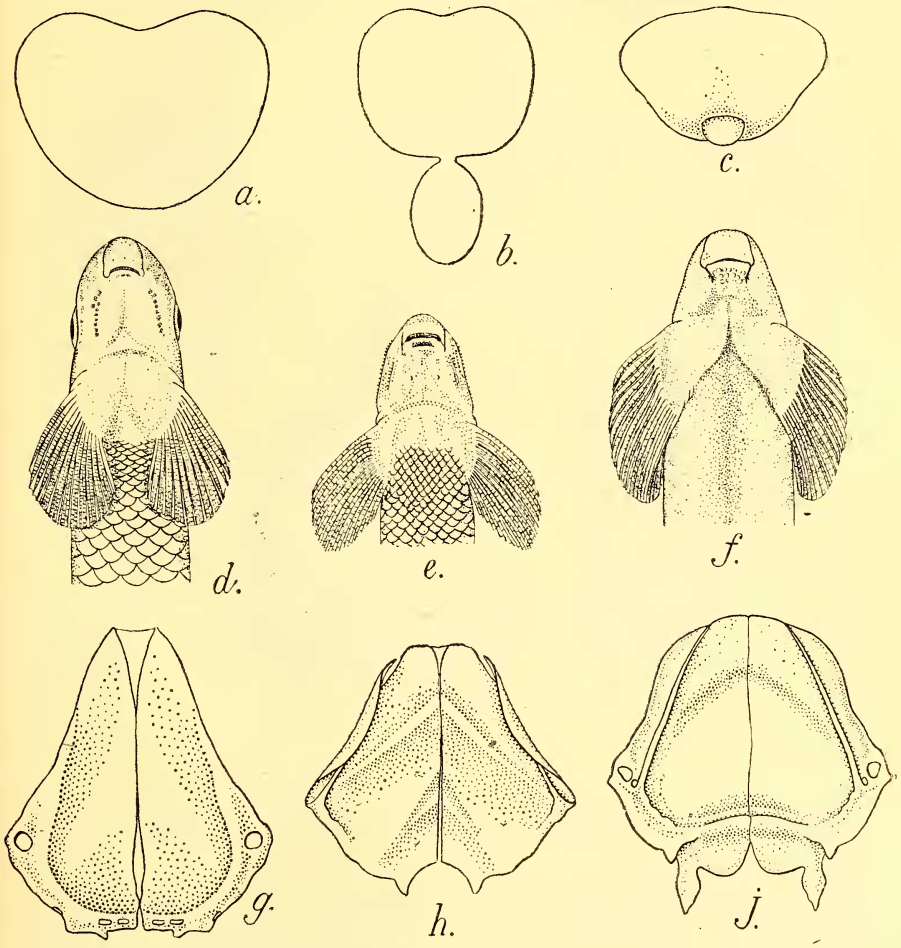

Fig. 1

Hora & Mukerji (loc. cit.) have already referred to the differences in the habitats of the three species and shown how these are correlated with their structural features. For instance, *P. sucatio* is usually met within sandy parts of a brook where it lies partly buried in sand which

it displaces with the vigorous action of its paired fins. It is thus not affected by the swiftness of the current to any appreciable extent. As a result of this ground habit of life, the air-bladder (text fig. 1*a*) has deviated from the normal shape and is represented by a laterally extended anterior chamber only. When it lies at the bottom, partly buried in sand, its dorsal streamlined profile offers little resistance to the current and the flattened ventral surface broadly rests on a sandy substratum. There seems little doubt that the unbranched rays in the

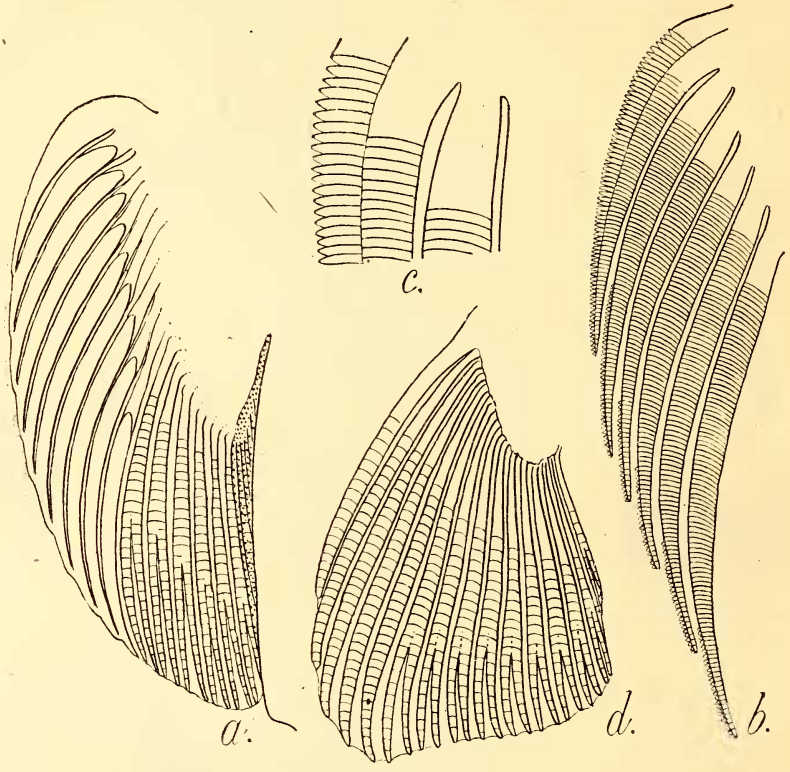

Fig. 2

paired fins of *P. sucatio* (text fig. 2*d*) are used for digging in sandy bottom. Similar structural modifications in the paired fins of the Homalopteridae (text fig. 2*a*) have taken place but for a different purpose—enabling them to cling to rocks. To obviate any damage to the fins, either when used for digging or for adhesion, the unbranched rays are completely segmented to ensure, during operation, pliability with strength. Thus the convergence of structure is carried a step further. In the case of the Homalopteridae, the skin on the ventral surface of these rays becomes padded (text fig. 2*a*) for effective adhesion and the first ray (text fig. 2*b* &c.) becomes broader by the development of a series of cartilaginous processes as are characteristic of the Glyptosternoid fishes (Hora & Silas, 1952) of the family

Sisoridæ. In view of the fact that the pectoral fins of *Psilorhynchus sucatio* are used for quite a different purpose, no adhesive pads of skin are developed on their ventral surface. In an aquarium, however, the fish was noticed to cling to the sides by means of the fins and the flattened ventral surface.

Psilorhynchus balitora (text fig. 1*e*) is cylindrical and loach-like in appearance and I have often collected it from rocky streams. Mukerji (op. cit., p. 830) observed that

> '*P. balitora* is found in the fast streams and shallow rivers of Northern Bengal and Assam, especially where the bottom is rocky. I have never found the fish living in any sluggish stream with a muddy bottom. In the Sevoke Stream and in the shallow, clear and rocky parts of the Mahanadi river, I have observed series of *P. balitora* adhering tightly to the rocky substratum with the expanded paired fins and the chest applied to the rocks. Like other torrential fishes, it always points its head against the flow of the current.'

On the other hand, Kaushiva (1951, p. 164) found specimens of *P. balitora* at Lucknow on a sandy bottom where the water was flowing with some force owing to a weir. There are more unbranched rays in the pectoral fins of this species than in *P. sucatio* and the air-bladder (text fig. 1*b*) is, though somewhat reduced, of the usual Cyprinid type, showing thereby that this species has not yet fully taken to a ground habit of life, though for clinging to rocks or digging in sand it seems to have more efficient pectoral fins than those of *P. sucatio*.

From the observations recorded above, it will be seen that *P. balitora* is equally at home both in rocky as well as in sandy streams. It is, therefore, a more generalised species of the genus. Specimens collected from the rocky streams usually possess skin pads on the ventral surface of the unbranched rays. The paired fins, originally modified for clinging to rocks have secondarily become equally efficient for digging in sand. Thus, this is a case of pre-adaptation, where structures modified for one purpose have turned out to be suitable for another purpose also.

Psilorhynchus homaloptera (text fig. 1*f*), as is implied in the specific name, has become absolutely *Homaloptera*-like in form and structural modifications. There is an increase in the number of unbranched rays to 8 in the pectoral fins and the air-bladder (text fig. 1*c*) is fibrous and reduced. Though no direct observations on its mode of life are recorded, the development of skin-pads on the ventral surface of the unbranched rays of the pectoral fins shows its adaptiveness to cling to rocks in swift currents.

The present-day modes of life of the three species referred to above indicate that *P. balitora* is the central form which can live in sand, as its specific name indicates, but is equally at home on rocks, as observed by Mukerji. It is not yet known which Cyprinoid genus gave rise to *Psilorhynchus* nor is there any indication about the evolution of the type of mouth characteristic of these fishes. The coalescence of the branched rays in the paired fins would seem to have been induced by digging in sand and later found useful for clinging to rocks also. The modifications of *P. sucatio* seem to be directed towards burrowing in sand while those of *P. homaloptera* for clinging to rocks. Thus in these three species we have a remarkable instance of functional divergence associated with structural convergence.

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Explanation of Text figures

Text fig. 1. Air-bladder, ventral surface of anterior part of body and basipterygium in the three species of *Psilorhynchus* McClelland.

a. Air-bladder of *P. sucatio* (Ham.) × 13; *b*. Air-bladder of *P. balitora* (Ham.) × 5 (After Mukerji, 1933) ; *c*. Air-bladder of *P. homaloptera* Hora & Mukerji, ×5 (After Hora & Mukerji, 1935); *d*. Ventral surface of anterior part of body of *P. sucatio* (Ham.) × *c*. 1 (After Hora 1921) ; *e*. Same of *P. balitora* (Ham.) × *c*. 1 (After Mukerji, (1933) ; *f*. Same of *P. homaloptera* (Hora & Mukerji, 1935). *c*. ×1 ; *g*. Basipterygium of *P. sucatio* (Ham.). × *ca*. 8 ; *h*. Same of *P. balitora* (Ham.), × *c*. 4½ (After Mukerji, (1933) ; *i*. Same of *P. homaloptera* Hora & Mukerji × *c*. 3. (After Hora & Mukerji, 1935).

Text fig. 2. Pectoral fins of *Balitora brucei* Gray and *Psilorhynchus sucatio* (Hamilton).

a. *Balitora brucei*: ventral surface to show the adhesive pads on the unbranched rays, × 2½ ; *b*. Six anterior rays of *B. brucei* dissected out to show their segmented nature and wing-like cartilaginous extensions on the exposed portions of these rays, × 4 ; *c*. Proximal portions of the anterior two rays of *B. brucei* to show the well-developed cartilaginous extension of the first ray, × 6⅓ ; *d*. *Psilorhynchus sucatio*.